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AN ECONOMETRIC TARGET SELECTION MODEL

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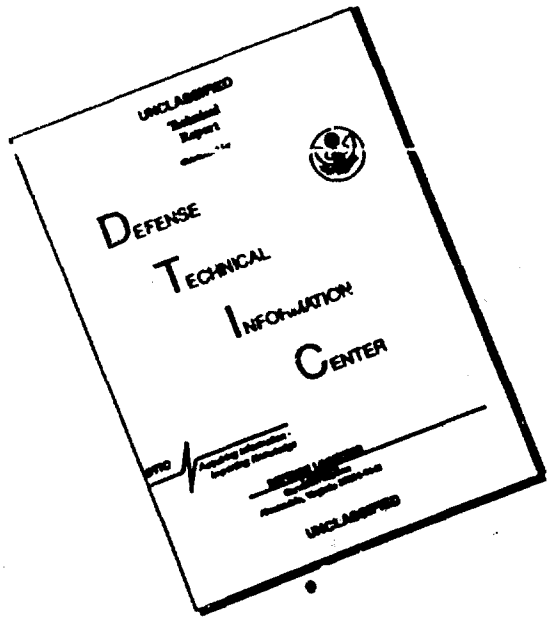

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TABLE OF CONTENTS

FIGURES

N ECONOMETRIC TARGET SELECTION MODEL

I Introduction

The purpose of this paper is to outline a procedure which will assist those who address the problems of target selection in any type of conflict and which will help the target analyst and operations planner choose more nearly optimal target complexes. This procedure employs the basic econometric technique of input/output analysis, but extends traditional input/output into a unique format which permits target selection to be made in a dynamic and cogent analytical environment. The model which is explained in the following pages is not intended to replace any of the current objective techniques of target analysis, but this approach will provide a display or focus which should make related studies more valuable.

Input/output as a specific tool of analysis was developed by the Harvard economist, W. W. Leontief. Leontief published the standard text on this technique in 1941, and since that time, a great amount of attention has been applied to the further development and sophistication of the methodology.

The econometric approach applied to target selection provides a logical framework of analysis for evaluating target interfaces, priorities, weights of effort, timing, and other relevant factors. The most productive plans for application of air power can be derived from careful

analysis of the total economic and military posture of the enemy. The input/output format provides the technique for interfacing potential targets in a set of displays which graphically indicate the significance and role of each target with respect to each of the other targets and to the entire economy.

Input/output was not initially developed or visualized as applicable to such problems as target selection. Wartime environments are not easily described by economic models because the frequent occurrence of conflicting events often violates the basic assumptions used to build the model. The fact that model validity suffers when employed for war analysis does not, however, imply that the methodology can not be useful in the target selection process. The model described in this paper is primarily intended to add new perspective to target selection. It can best be used by the well-informed target analyst to broaden his grasp of target priorities and to assist in evaluating the implications and impacts of specific applications of air power.

A model similar to that described herein was completed in February 1967 and has been applied to target planning for North Vietnam.

II Target Model Development

A. Concept

Input/output analysis of an economic system (a) takes advantage of the relatively stable pattern of the flow of goods and services among the elements of the economy to provide an objective picture of the system, and (b) places the various sectors of an economy within a structure which is suitable for theoretical analysis and hypothetical manipulation. The first step in input/output analysis is the partitioning of all the firms (public and private) of a given country into a number of mutually exclusive sectors. A highly detailed analysis might identify as many as 250 different sectors and more concise efforts might identify 30 or less. As a minimum, three main sectors must be identified: agriculture, industry, and services. The services sector would include banking, trade, hotels, education, military, transportation and other similar activities. Every firm is placed in only one sector even though this may require seemingly arbitrary assignment.

The format of input/output is a matrix, and the essential principles of the method may be most easily comprehended with reference to Figure 1. This figure illustrates the 42 sector table developed by the Bureau of Labor Statistics for the United States economy. Input/output interactions are identified within the matrix cells which

are intended to contain the coefficients which show the degrees of interdependence which exist within an economy. The vertical and horizontal axes are identically labeled; the horizontal rows show how the output of each sector of the economy is distributed to support the other sectors. Conversely, the vertical columns show how each sector obtains from the others its inputs of goods and services. The output of each sector is therefore shown as the input to some other. This double-entry bookkeeping of the input/output table thus reveals the fabric of the economy in question, woven together by the flow of trade which ultimately links each branch of agriculture, industry, and services. A table of this type may be developed in as fine or as coarse detail as the available data permit and the purpose requires.

The input/output coefficients which apply in specific matrix cells to indicate the quantitative degree of interrelationships can be determined from analyses of national accounts (where available), the current state of industrial technology of the economy under consideration, and from the institutional patterns which establish the national political and economic environment.

While coefficient determination is essential for conventional uses of input analysis, its use for target analysis will not require that all coefficients be determined because the explicit purpose of target selection is

to interrupt normal economic processes by destroying industrial and military installations. Peacetime coefficients and industrial inter-relationships can be expected to change as war-related pressures influence a belligerent nation. An input/output model for target use should investigate minimum input coefficients, substitute input coefficients, and the projected corresponding degrees of interdependence which exist within the most vital sectors of an economy.

B. Model Structure

There is no single best approach to building a target model of this type. Model structure and model routines should be developed to correspond to the individual economy which is subject to attack in such a way that the targets may be selected with reference to any current constraints, priorities, or other relevant factors. Major changes in the environment of the conflict will therefore require a re-evaluation of the target model to be certain that the original assumptions which were employed in the model are currently valid.

1. Selection of the Target Economy

The selection of the target economy is frequently a response rather than an initiation. An attack or the imminent threat of aggression against a friendly nation by a hostile force automatically selects a candidate for the target model. Care should be exercised in the physical definition of the enemy economy to insure that the target model will include all relevant domestic enemy activities.

2. Definition of Economic Sectors

The analysis will attempt to take account of the interdependence of production plans and activities of the many industries which constitute an economy. This interdependence arises out of the fact that each industry employs the outputs of other industries as its raw materials. Its output, in turn, is often used by other producers as a productive factor. The end product of any economy is that which is used directly by the consumer (the domestic population, military, etc.). Figure 1 illustrates the decomposition of the American economy into 42 sectors. The analyst who is developing an econometric model will try to fit the economy in question in a set of sectors similar to those of Figure 1. If the analyst is especially interested in certain sectors; e.g., military, electronics, etc., he can expand the sector list to separate these categories into independent entries. In general, it will be to the advantage of the model developer to have as few categories as possible. An underdeveloped economy will not have as many sectors as a more developed one, and if the enemy economy does not have domestic entries in non-final categories, these categories should be omitted. For example, if the enemy does not have a domestic output of raw copper or an internal requirement for copper, this potential category would be left out.

3. The Basic Econometric Matrix

The basic format is established by listing all the sectors chosen in para 2 on the two axes of a matrix. If the sectors have been selected carefully, this matrix will provide a device which will illustrate the internal interdependencies which exist within the subject economy. The identification of these interdependencies requires a knowledge of the economy as to:

a. The types of industry present, their product mix, and capacities;

b. The state or level of technology in each industry;

c. The availability of resources; and

d. The economy's import-export pattern.

This matrix will be completed (if data are available) in a three-stage sequence.

The first stage of matrix development will attempt to identify only the existence of inter-relationships between the sectors listed on the left and those same sectors listed across the top without any attempt toward quantification. The analyst traces the output (goods and services) of the sectors as they move from left to right across the matrix; and if the output of a particular sector is required by one of the sectors listed across the top of the matrix to produce its product, then a dot (or check mark) is placed in the matrix cell which joins the two sectors. This procedure defines the "input/output"

process in which cells are identified which internally link the economy sector by sector. These dots are placed in matrix cells only where there is an essential and continuing input/output relationship.

The second stage of matrix development should examine the technological, engineering, and institutional relationships which exist within those matrix cells which were dotted in stage one. This matrix will illustrate the quantitative input requirements of the sectors listed across the top from those listed vertically to produce one arbitrarily defined unit of output. For example, if one of the sectors listed horizontally is processed steel, this matrix could define a unit of processed steel as being one ton and the vertical column below the sector "steel" would indicate the necessary inputs and their quantitative proportions to produce one ton of steel. The exact coefficients and the distribution of coefficients within this type of matrix will vary widely among differing economies, but this matrix, once it is defined for a particular economy, will display a high degree of stability over time.

The third stage matrix defines the flow of goods and services within the economy with respect to monetary values. Its purpose is solely to present the flow of currency transactions which match the flow of physical transactions over a specified time period (usually a year). This matrix is sometimes difficult to develop and interpret because of circumstances which create a lack of reliance on a market economy for

distribution of goods and services in the target nation. In an underdeveloped or socialized economy (or in one which is both) many physical transactions are made without a monetary reference, and therefore the analyst will have to impute values for these activities with reference to what the goods or services would be worth on the world market or within his own country. This type of assessment is more frequently misleading than instructive. For those interested in target selection too much concern in the monetary value of potential targets is unfortunate when monetary values, as we impute them, are not suitable gauges for the utilities provided to the nation by the sectors which are interfaced in this third stage matrix. Although not absolutely required for the development of a useful econometric target model, this matrix does provide the common denominator of dollars for all cell entries which in turn permits a wide variety of matrix input/output coefficients to be computed.

The role that imports and exports play in a given economy may be vitally significant for target analysis. In the construction of the three stages of matrices listed above, the analyst should separately identify or code those matrix cells which are supported through importing and those industries which produce a domestic surplus and therefore are exporters. This will permit the user of the target model more easily to evaluate the role that trade assumes in the enemy economy and to evaluate the domestic impact which would result from trade interruption. The knowledge provided by the matrices of the

import and export (foreign exchange) requirements of the enemy country also permits the analyst to more precisely estimate any covert support which may be provided to the enemy.

4. Target Matrices

The discussion in para 3 above derives directly from the development of a standard economic input/output model suitable for peacetime monitoring and research. These matrices interface the individual economic sectors; however, they do not provide a complete format for establishing target priorities for target complexes. Since these basic matrices do delineate all of the activities within the nation which serve to make goods and services available, the target matrices will be developed by a process which combines and aggregates these economic sectors into target categories. The precise composition of these target categories will depend in large part on the stated policy of the U.S. and friendly nations and on the frequency and depth of developed economic interdependencies. These target categories might include such basic factors as POL, electric power, agriculture, ports, lines of communication, and other similar complexes. It will be obvious that in limited wars and especially those with many targeting constraints this listing of target categories will be more limited and selective than in general war.

The first target matrix will interface the economy with the chosen target categories. The matrix will list the economic sectors described in para 3 above on the vertical axis and the target categories across the horizontal. An analysis is then

required to investigate how the economy supports the target categories. If data availability permitted the three stage economy-to-economy matrices to be developed, the economy-to-target matrix format can be completed in the same fashion. The sequential insertion of the dots, technological coefficients, and monetary values are derived through reference to the applicable economy-to-economy matrices. Figure 2 is an example of the economy-to-target matrix.

The second target matrix will interface target categories to target categories. The same target categories selected above will be listed vertically and horizontally on the matrix and the analysis will delineate how the target categories support each other as they aggregately support the prosecution of the war effort against the friendly nations. The target-to-target matrix should be expanded through the three stages as described for the basic economy matrices. This aggregated target-to-target matrix will make a useful reference for higher level planners. Figure 3 is an example of the target-to-target matrix.

The third target matrix, which is the most important tool for the working target analyst, is a highly detailed expansion of the aggregate target-to-target matrix discussed above. This matrix set requires the greatest degree of detailed intelligence data to break out the target categories into the separate components which comprise each grouping. The matrix rows and columns will list individually the major

industrial sites, power plants, military installations, ports, distribution points, and the other components which constitute the enemy's economic and military establishment. This matrix will illustrate how each potential target fits into the aggregate fabric of the enemy's processes; it will indicate how the target is supported and, in turn, those other targets which are being supported by this target. If it is possible, this detailed target-to-target matrix should be expanded through the three stages. However, this matrix can provide a very valuable contribution if only the first stage is completed.

III Target Selection

The process of target selection through the use of an econometric model is one which permits the analyst to estimate the scope or envelope of disruption that the partial or total removal of a physical site would have on enemy capabilities. The model also permits the analyst to anticipate the type of internal reorganization that the enemy would most likely pursue to accommodate to bomb damage. Target evaluation techniques which are based on the demonstrated interdependencies illustrated in the matrices provide an efficient methodology for selecting target complexes. This target selection procedure is not one which is automatic; nor will use of the matrices lead the analyst to an optimum target mix. These matrices provide a quantitative series of displays which interface all targets, and from these interfaces the target analyst can

remove much of the subjectivity from the selection process. Final selections, however, will remain as a subjective choice.

The displayed interdependencies can show how targets can become temporarily compromised without being directly struck, by striking other targets which provide vital inputs to the subject target. If it is desired to put a target out of commission for a maximum period, one should strike that high priority target, then strike the categories which input the target, and finally strike the targets which complement and substitute for the subject target. Proper target selection combinations will depend on each individual environment.

The analyst should be especially alert for those factors which will tend to frustrate the user of an econometric approach to targeting. A major frustration will be provided by the enemy's ability to substitute. Substitutability can assume many forms, and these potentialities for substitution should be identified, as best as possible, prior to target selections. If time and analytical resources permit, "substitution trees" can be developed to structure the substitution options of the enemy. These trees may take any form that the analyst requires, however they should include the types of information illustrated in Figure 4. In this figure are delineated possible substitution patterns for target A, indicating that B and C are potential substitutes for A. The analyst should be aware that if A is destroyed and if B or C (or combinations of each) are easily substituted then the effectiveness of this target removal

is compromised. Certain facts about the substitution capability of categories of the B and C type must therefore be known. As a minimum, the following three general lines of inquiry should be followed for each potential substitute:

1. What categories does the potential substitute now serve? If substitute B and C products are largely demanded by low priority (in terms of the war effort) users, then it would be a relatively painless process for the enemy to switch to B or C as a replacement for A.

2. What is the capacity of each of the substitution candidates? If these categories are operating at less than capacity, then a simple increase in output may be the enemy's solution to the problems posed by destruction of A.

3. What are the technological implications of substituting either B or C for A? Will the substitution be achieved only through a large sacrifice in productivity?

There are many other facets of substitutability which can be studied, and these will be apparent to the analyst. Figure 4 also indicates that these substitution trees can be carried to a secondary level which involves D and E as substitutes for B, and F and G as substitutes for C.

Another problem which is related to substitutability is that of inventories or stocks of critical materials which the enemy may have in storage. If storage sites are hidden or inaccessible, the effectiveness of striking particular targets may be reduced by the availability of critical materials in

stock piles. The ability to import on the part of the enemy nation may have the same effect as an unlimited inventory. The beneficial effect of the stockpiles and imports to the enemy may be reduced by strikes on transportation networks, vehicles, and ports.

A high value, highly interdependent target system may be so hardened and/or dispersed that the weight of effort for destruction is prohibitive. The target matrices then become valuable for selecting the most effective alternate to achieve the same objective.

This econometric targeting approach must include periodic adjustments for military dynamics. The matrices which are established prior to a major attack must be altered to reflect the results of the attack. In general, these periodic alterations will not change the labeling of the axis of the matrices; they will however affect the internal interdependencies. And, of course, the reconstitution efforts of the enemy will require periodic updating as intelligence indications of repair of previously destroyed targets is received.

TABLE 1. INPUT-OUTPUT FLOWS THE EXCHANGE OF GOODS

INDUSTRY

A.

B.

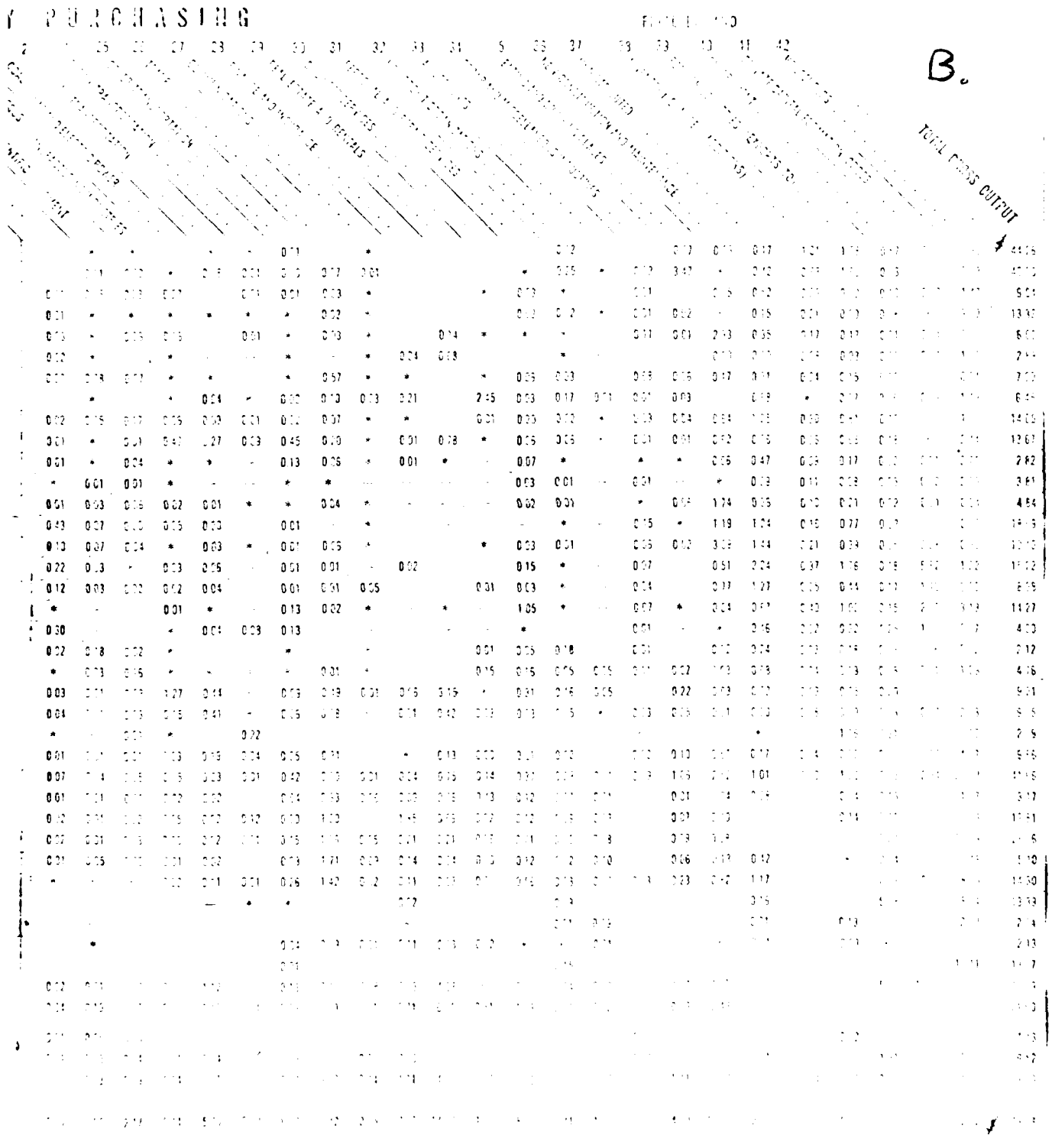

Figure 2

ECONOMY - TO - TARGET MATRIX

Figure

TARGET - TO - TARGET MATRIX

Target Groupings → / ↓	Electric Power	POL	Airfields	Military Supplies	Ports	Trucks	Aircraft	Other
Electric Power								
POL								
Airfields								
Military Supplies								
Ports								
Trucks								
Aircraft								
Other								

FIGURE 4

SUBSTITUTION TREE